



# Unfold a 3D Object into a Flat Pattern

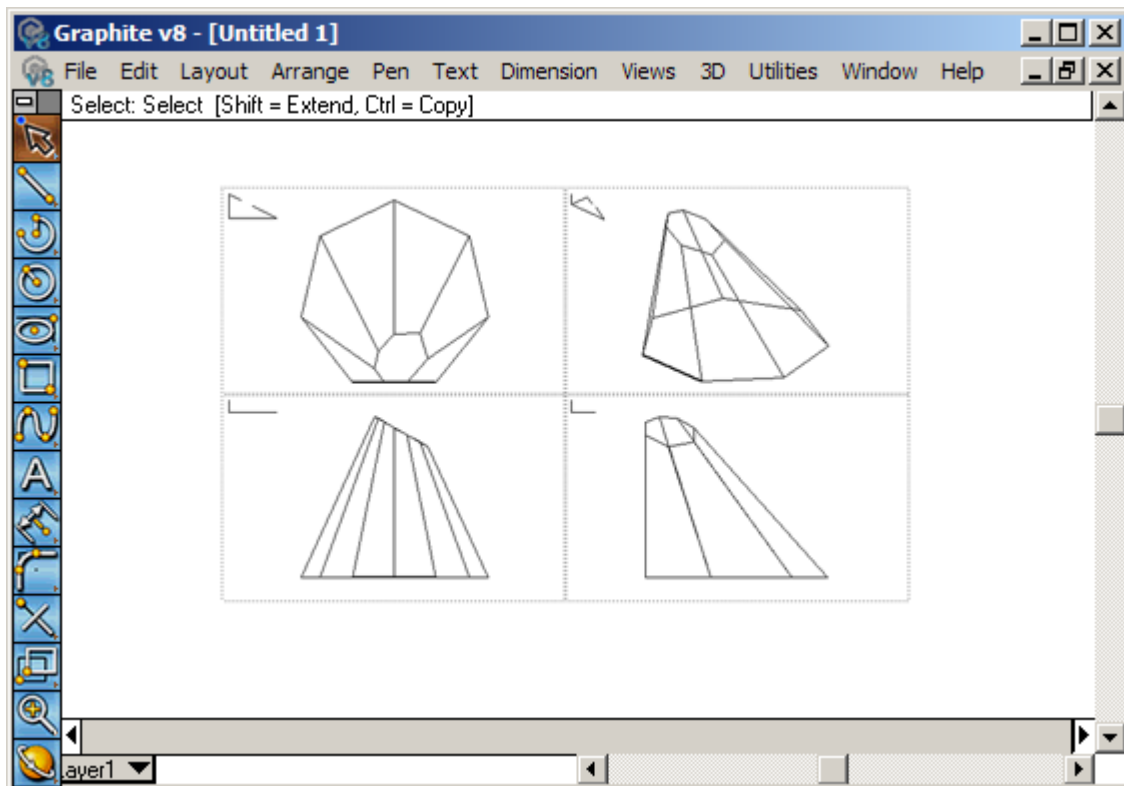
*Using Graphite™*

# Unfold a 3D Object into a Flat Pattern

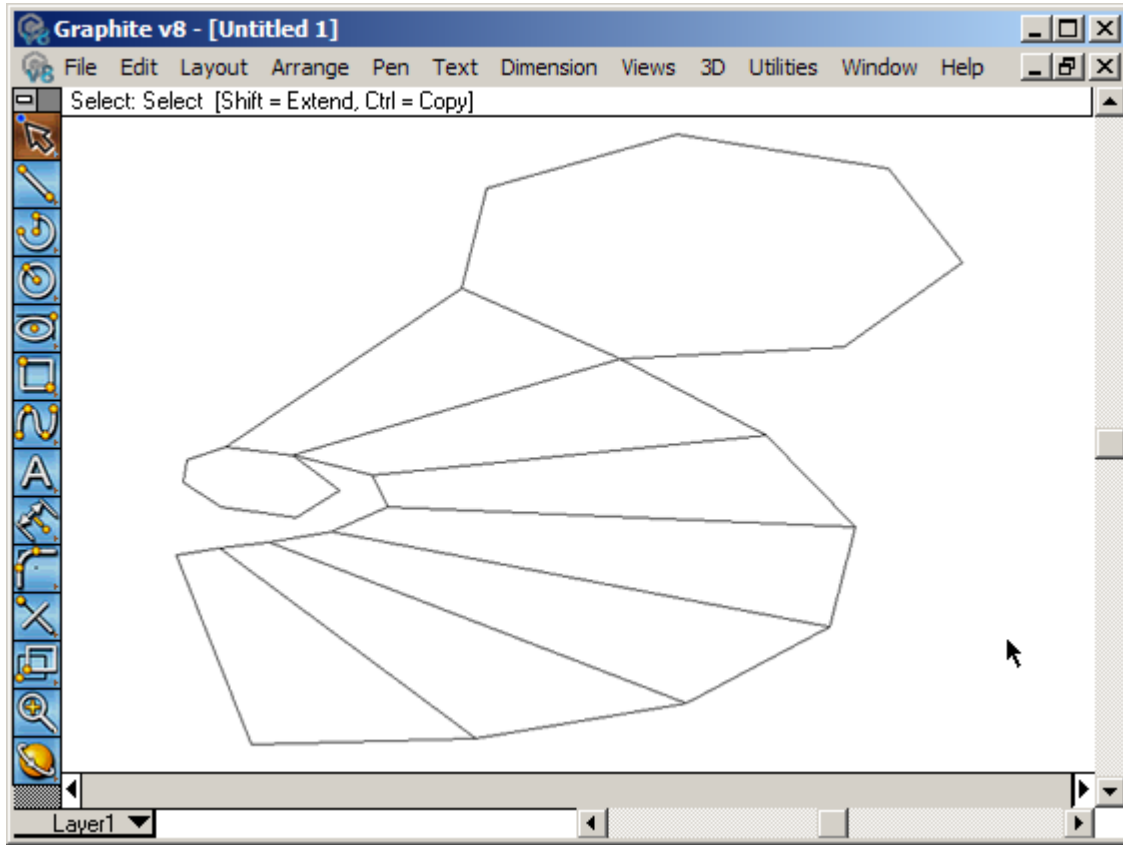
Working in Graphite, it is possible to create a flat pattern from a 3D object by unfolding it. This tutorial requires full understanding of the previous tutorial, *Creating and Defining Angled Planes*, as we will use it extensively here. Unfolding an object into a flat pattern is necessary when building the part with sheet metal or cardboard.

We will use a simple skewed Pyramid whose top has been sliced off as an example. It is possible to unfold the pyramid by rotating each face until it rests flat on the Top plane. These rotation operations require orienting the Z-axis along each hinge-line of the pyramid while working your way around the part.

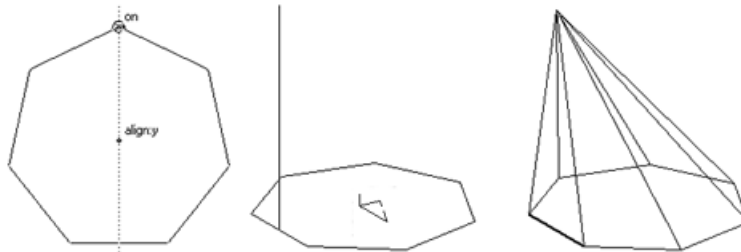
The actual 3D part looks like this:



When this part is unfolded its flat pattern looks like this:

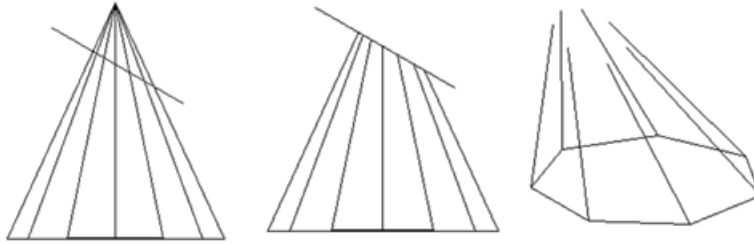


1. In the Top Plane, draw a seven-sided polygon where the lowest line is horizontal.  
*The orientation of this polygon will be important later. The horizontal line here is shown slightly bolder, the size of the objects are not important.*



2. Switch to Trimetric View and draw a single vertical line in the Z-direction starting at the midpoint of the horizontal line segment.  
*A small Triad is shown here just for reference.*
3. Use the top of the vertical line as the vertex of the pyramid and draw seven lines from there to the corners of the polygon. Delete the original line.

4. Switch to Front View and switch to Front Plane. Draw an angled line something like the one shown here.



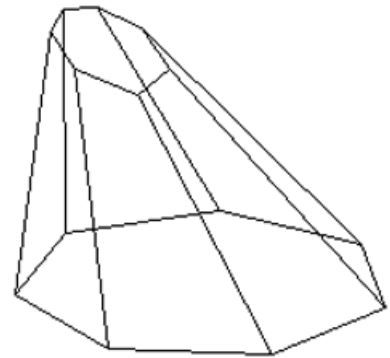
5. Use the Simple Trim tool to cut off all the lines that appear above the new line.

*This boundary line acts as an infinite trimming plane and slices through everything that is closer to you or farther away from you. The result is a number of chopped-off lines.*

6. Use the Connected Line tool to connect these lines.

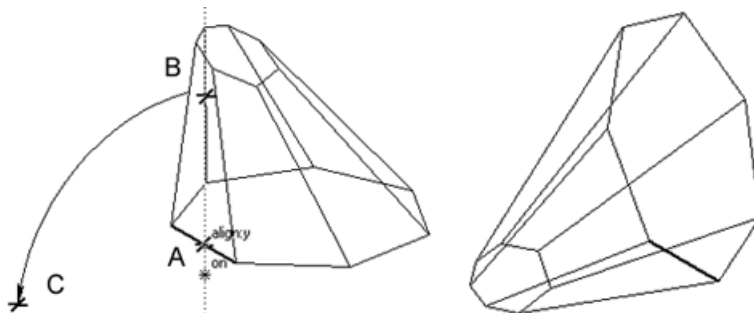
*This completes the 3D figure for the exercise.*

Now we are going to unfold this pyramid by first tipping it over on its side, then unfolding its caps, and then un-rolling the body.



7. Switch to Right Plane.

*This puts the Z-axis pointing the same direction as the original horizontal line of the polygon.*



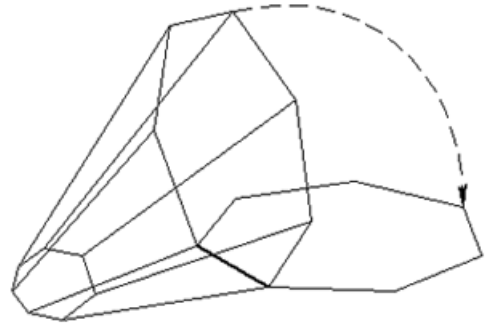
8. Using the Rotate tool, click at points A, B and C to rotate the part 90° so that it is resting on its side.

*B is aligned with A along the Y-axis, and C is aligned with A along the X-axis. You could also click at point A and then type 90 into the Angle field in the Status Line and press the Enter key. The result is shown above.*

- Select all the lines of the base polygon (except the bold one) by shift-clicking on them with the Selection tool.

*Select six lines because when this cap is unfolded, a copy rotates. It is not necessary that this bold line duplicates itself.*

- Using the Rotate tool, click once anywhere on the bold hinge line and then type -90 (negative 90) into the Angle data field in the Status Line, hold the Ctrl (PC) or Option (Mac) key and press the Enter key.



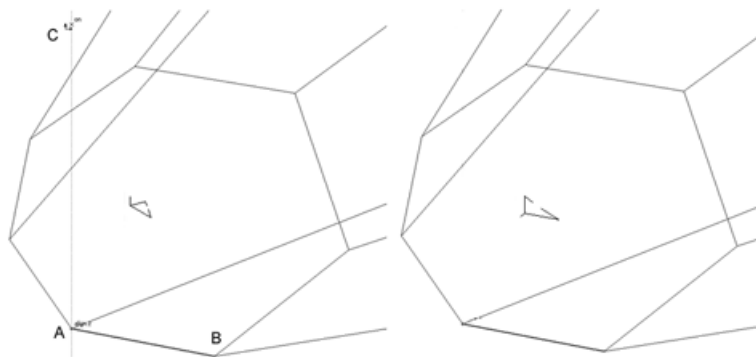
*A copy of the bottom cap will rotate down as if it were unfolded.*

To unfold the top cap rotate it about the line that is laying flat on the ground. This line currently does not line up with the X, Y or Z-axis, so you need to get the Z-axis pointing in the same direction as this hinge-line. This is our first chance to take advantage of the methods used in the previous Tip.

For the first unfold operation, we will use the **3-Point Plane** method.

- Switch back to Top Plane.
- Pick the 3-Point Plane command from the 3D menu.
- Click at points A, B and C to set the Origin, X, and Y-axis.

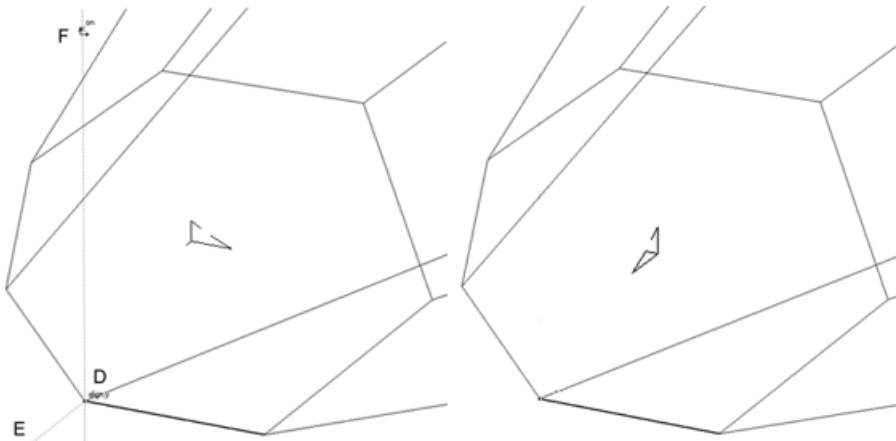
*The triad shown in the left image below is for the Top plane (which is your current plane). Note that points A and B are on the hinge-line. Point C is aligned with A along the Z-axis. The orientation of the new Work Plane (it is the Temp Plane in the Planes menu) is shown with the triad in the right image below. The X-axis is parallel to the hinge-line and the Y-axis is straight up.*



- Pick the 3-Point Plane command again.

15. Now click at points D, E, and F to define the final 3-Point Plane.

*Point E is aligned with Point D along the current-Z-axis and Point F is aligned with Point D along the current Y-axis. This is how the second 3-Point Plane operation always works. The first click goes back on the same origin. The second click always aligns on the current Z-axis, and the third click always aligns on the current Y-axis. Follow this procedure, and the final Work Plane will end up with its Z-axis pointing in the right direction. The orientation of the new Work Plane is shown with the triad in the right image below.*



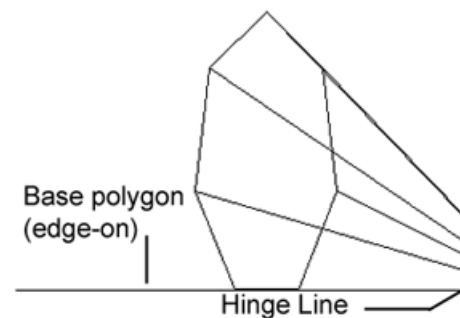
The Z-axis now points in the same direction as the hinge-line. It is possible now to rotate the end cap and lay it flat onto the Top plane.

16. Select the six polygon lines above the hinge-line.

*Again, rotate a copy and do not make the hinge-line duplicate itself.*

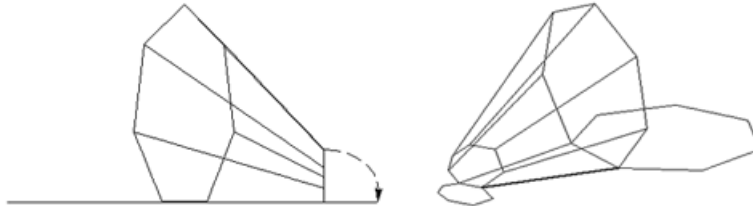
17. From the Views Menu, choose View the Plane.

*This causes Graphite to change the view to show this new Work plane just defined. You will be looking down the Z-axis of this Temp plane. The X-axis will point to the right and the Y-axis will point straight up. The Z-axis is coming out of the screen. The hinge-line looks like a point since it is now seen from the end.*



- With the Rotate tool, click on the hinge-point to set the pivot point. Hold the Ctrl (PC) or Option (Mac) key and drag the small polygon (which now looks like a line) down  $90^\circ$  to rotate it from vertical to horizontal.

*You could also click on the pivot point and then type  $-90^\circ$  (negative 90) into the Status Line, hold the Ctrl or Option key and press the Enter key. Without knowing an exact rotation angle, drag the selected objects through the rotation angle.*



Next, unroll the body of the pyramid by continuing with the same methods doing a series of rotations that will ultimately give a flat pattern.

Do the first rotation with the right edge of the body-segment that is already resting flat on the Top plane as a hinge-line. Get the Z-axis pointing in this same direction. This time use the **Define View** method.

- Set the plane to Top and then choose the Define View command from the Views Menu.
- In the resulting dialog box, click the New button.

*The Redefine View dialog box appears.*

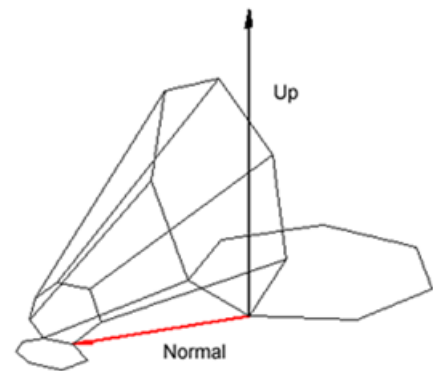
- The dX field for the Normal vector is highlighted. Drag the cursor along the hinge-line, from the big polygon end to the small polygon end. This line acts as the line-of-sight.
- The dX field for the Up vector becomes highlighted. Drag the cursor up along the current Z axis alignment from bottom to top. This vector appears vertical in the new view.

*A new view called **View 1** appears in the list displayed in the Define View dialog box.*

- Select all of the lines belonging to the body of the pyramid that are above the Top plane.

*These lines will be rotated. Select these lines now because it is easier to do in a Trimetric View.*

The line-of-sight vector is now parallel to the hinge-line. The Work plane needs to be set so that the Z-axis is parallel to the hinge-line.

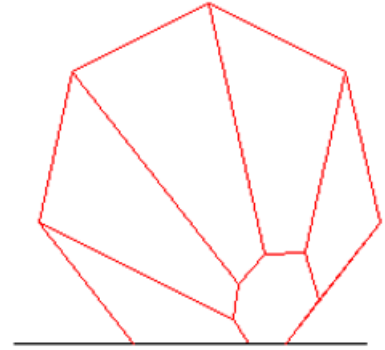


- Change the view to the new View 1.

25. From the 3D menu, choose Set Plane to Screen.

*This sets the triad so the Work Plane matches the current screen. A TempPlane is created in the Planes menu.*

When the **Set Plane to Screen** command is executed, the Triad will always show the Work Plane set parallel to the current screen. The Z-axis is always coming out of the screen. It stays in this mode until a specific plane (like Top plane) is selected the next time from the Planes menu.



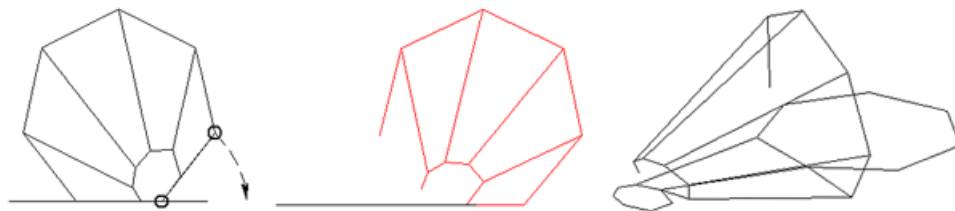
26. From the 3D menu, choose Define Plane. Click on the new TempPlane so that its name appears in the Rename field. Type in a new name, like Plane A and click the Rename button.

*By renaming this temporary plane, make it a permanent plane. It is not necessary to do this step if you stay in **View 1** to do the rotation. If you are not in **View 1**, any changes to the view with the Trackball or the planes menu will change this Work Plane and prevent the rotation of the part.*

The first face of the pyramid body is resting on the Top plane. Now rotate the rest of the pyramid about the designated hinge-line until the second face comes to rest on the Top plane.

27. Make sure all the pyramid lines are still selected. Use the Rotate tool and click right on the hinge-point to set the pivot point. Grab the upper end of that line and drag it down until it rests in the horizontal plane.

*The result is shown in the middle and right figures below. Add in a single line to replace the line that did not get rotated.*



Continue defining a new hinge-line and shifting the Work plane so that the Z-axis follows that line, until this entire part is unfolded.

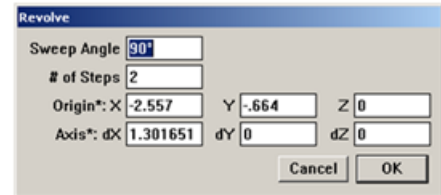


## BONUS TIP:

Another way to rotate 3D objects is to use the **Revolve** command in the 3D menu. This method defines an exact axis of revolution oriented anywhere in 3D space without generating a new plane to get the Z-axis pointing the right way. It works when the exact angle of rotation is known. For example, the rotation that is done in Steps 7 and 8 above where the pyramid is first tipped over on its side can be done using the Revolve command.

1. Select the Entire pyramid and group it.
2. Pick the Revolve command from the 3D menu.

*The Revolve dialog box comes up.*



3. Enter 90 for Sweep Angle and 2 for Number of Steps.
4. Highlight the Origin X data field. Drag the bulls-eye cursor from point A to point B to indicate the axis of revolution and click the OK button.

*A copy of the pyramid tips onto its side and all the sweep lines appear.*

5. Select all the geometry. Hold the Shift key and deselect the new rotated pyramid.
6. Delete all the selected geometry.

The rotated pyramid remains.

